

be more easily made by melting together 37 parts of lead and 63 parts of tin (exactly measured).

Soldering irons are usually made of copper, as copper is easily heated and easily gives up its heat to the solder. The point of the iron must be "tinned." To do this properly, the iron should be heated hot enough easily to melt the solder; the point should then be quickly dressed with a smooth flat file to remove the oxide, and rubbed on a piece of tin through solder and sal ammoniac. The latter causes the solder to adhere in a thin, even coat to the point of the iron. A gas or gasoline blow torch or a charcoal furnace is best for heating the iron, but a good, clean coal fire, well coked, will answer the purpose.

When in use, the iron should be hot enough to melt the solder readily. A cold iron produces rough work. This is where the beginner usually fails. If possible, it is well to warm the pieces before applying the iron. The iron must not be heated too hot, however, or the tin on the point will be oxidized. The surfaces to be soldered must be clean. Polish them with sandpaper, emery cloth, a file, or a scraper. Grease or oil will prevent solder from sticking.

Some good soldering fluid should be used. A very good fluid is made by dissolving granulated zinc in muriatic acid. Dissolve as much zinc as possible in the acid. The gas given off will explode if ignited. To granulate the zinc, melt it in a ladle, and pour it slowly into a barrel of water. A brush or swab should be used to spread the fluid on the surfaces to be soldered. If the point of the soldering iron becomes dirty, it should be wiped on a cloth or piece of waste that has been dampened with the soldering fluid.

**Soldering of Metallic Articles.**—In a recently invented process the parts to be united are covered, on the surfaces not to be soldered, with a protective mass, which prevents an immediate contact of the solder with the surfaces in question, and must be brushed off only after the soldered pieces have cooled perfectly, whereby the possibility of a change of position of these pieces seems precluded.

For the execution of this process the objects to be soldered, after the surfaces to be united have been provided with a water-glass solution as the soldering agent and placed together as closely as possible or united by wires or rivets, are coated in the places where no solder is desired with a protective mass, consisting essentially

of carbon (graphite, coke, or charcoal), powdered talc or asbestos, ferric hydrate (with or without ferrous hydrate), and, if desired, a little aluminum oxide, together with a binding agent of the customary kind (glue solution, beer).

Following are some examples of the composition of these preparations:

I.—Graphite, 50 parts; powdered coke, 5 parts; powdered charcoal, 5 parts; powdered talc, 10 parts; glue solution, 2.5 parts; drop beer, 2.5 parts; ferric hydrate, 10 parts; aluminum oxide, 5 parts.

II.—Graphite, burnt, 4 parts; graphite, unburnt, 6 parts; powdered charcoal, 3 parts; powdered asbestos, 1 part; ferric hydrate, 3 parts; ferrous hydrate, 2 parts; glue solution, 1 part.

The article thus prepared is plunged, after the drying of the protective layer applied, in the metal bath serving as solder (molten brass, copper, etc.), and left to remain therein until the part to be soldered has become red hot, which generally requires about 50 to 60 seconds, according to the size of the object. In order to avoid, in introducing the article into the metal bath, the scattering of the molten metal, it is well previously to warm the article and to dip it warm. After withdrawal from the metal bath the soldered articles are allowed to cool, and are cleaned with wire brushes, so as to cause the bright surfaces to reappear.

The process is especially useful for uniting iron or steel parts, such as machinery, arms, and bicycle parts in a durable manner.

**Soldering Acid.**—A very satisfactory soldering acid may be made by the use of the ordinary soldering acid for the base and introducing a certain proportion of chloride of tin and sal ammoniac. This gives an acid which is superior in every way to the old form. To make 1 gallon of this soldering fluid take 3 quarts of common muriatic acid and allow it to dissolve as much zinc as it will take up. This method, of course, is the usual one followed in the manufacture of ordinary soldering acid. The acid, as is well known, must be placed in an earthenware or glass vessel. The zinc may be sheet clippings or common plate spelter broken into small pieces. Place the acid in the vessel and add the zinc in small portions so as to prevent the whole from boiling over. When all the zinc has been added and the action has stopped, it indicates that enough has been taken up. Care must be taken to see that there is a little zinc left in the bottom, as other-



wise the acid will be in excess. The idea is to have the acid take up as much zinc as it can.

After this has been done there will remain some residue in the form of a black precipitate. This is the lead which all zinc contains, and which is not dissolved by the muriatic acid. This lead may be removed by filtering through a funnel in the bottom of which there is a little absorbent cotton, or the solution may be allowed to remain overnight until the lead has settled and the clear solution can then be poured off. This lead precipitate is not particularly injurious to the soldering fluid, but it is better to get rid of it so that a good, clear solution may be obtained. Next, dissolve 6 ounces of sal ammoniac in a pint of warm water. In another pint dissolve 4 ounces of chloride of tin. The chloride of tin solution will usually be cloudy, but this will not matter. Now mix the 3 solutions together. The solution will be slightly cloudy when the 3 have been mixed, and the addition of a few drops of muriatic acid will render it perfectly clear. Do not add any more acid than is necessary to do this, as the solution would then contain too much of this ingredient and the results would be injurious.

This soldering acid will not spatter when the iron is applied to it. It has also been found that a poorer grade of solder may be used with it than with the usual soldering acid.

#### ALUMINUM SOLDERS.

To solder aluminum it is necessary previously to tin the parts to be soldered. This tinning is done with the iron, using a composition of aluminum and tin. Replace the ordinary soldering iron by an iron of pure aluminum. Preparation of aluminum solder: Commence by fusing the copper; then add the aluminum in several installments, stir the mixture well with a piece of iron; next add the zinc and a little tallow or benzine at the same time. Once the zinc is added do not heat too strongly, to avoid the volatilization of the zinc.

I.—Take 5 parts of tin and 1 part of aluminum. Solder with the iron or with the blowpipe, according to the article in question.

II.—The pieces to be soldered are to be tinned, but instead of using pure tin, alloys of tin with other metals are employed, preferably those of tin and aluminum. For articles to be worked after soldering, 45 parts of tin and 10

parts of aluminum afford a good alloy, malleable enough to be hammered, cut, or turned. If they are not to be worked, the alloy requires less aluminum and may be applied in the usual manner as in soldering iron.

Aluminum Bronze.—I.—Strong solder: Gold, 89 parts; fine silver, 5 parts; copper, 6 parts.

II.—Medium solder: Gold, 54 parts; fine silver, 27 parts; copper, 19 parts.

III.—Weak solder: Gold, 14 parts; silver, 57 parts; copper, 15 parts; brass, 14 parts.

#### BRASS SOLDERS.

Brass solder consists of brass fusible at a low temperature, and is made by melting together copper and zinc, the latter being in excess. A small quantity of tin is often added to render the solder more fusible. Hard solders are usually sold in the form of granules. Although many workers in metals make their own solder, it is advisable to use hard solder made in factories, as complete uniformity of quality is more easily secured where large quantities are manufactured.

In making hard solder the melted metal is poured through birch twigs in order to granulate it. The granules are afterwards sorted by passing them through sieves.

When brass articles are soft-soldered, the white color of the solder contrasts unpleasantly with the brass. If this is objected to, the soldered part can be colored yellow in the following manner:

Dissolve 10 parts of copper sulphate in 35 parts of water; apply the solution to the solder, and stir with a clean iron wire. This gives the part the appearance of copper. To produce the yellow color, paint the part with a mixture consisting of 1 part of a solution of equal parts of zinc and water (1 part each) and 2 parts of a solution of 10 to 35 parts respectively of copper sulphate and water and rub on with a zinc rod. The resulting yellow color can, if desired, be improved by careful polishing.

The quality of soft solder is always judged in the trade from the appearance of the surface of the castings, and it is considered important that this surface should be radiant and crystalline, showing the so-called "flowers." These should be more brilliant than the dull background, the latter being like mat silver in appearance. If the casting has a uniform whitish-gray color, this is an indication that the alloy contains an insufficient quantity of tin. In this case

the alloy should be remelted and tin added, solder too poor in tin being extremely viscid.

Most of the varieties of brass used in the arts are composed of from 68 to 70 per cent copper and from 32 to 30 per cent zinc. Furthermore, there are some kinds of brass which contain from 24 to 40 per cent zinc. The greater the quantity of zinc the greater will be the resemblance of the alloy to copper. Consequently, the more crystalline will the structure become. For hard soldering only alloys can be employed which, as a general rule, contain no more than 34 per cent of zinc. With an increase in copper there follows a rise in the melting point of the brass. An alloy containing 90 per cent of copper will meet at 1,940° F.; 80 per cent copper, at 1,868° F.; 70 per cent copper, at 1,796° F.; 60 per cent copper, at 1,742° F. Because an increase in zinc causes a change in color, it is sometimes advisable to use tin for zinc, at least in part, so that the alloy becomes more bronze-like in its properties. The durability of the solder is not seriously affected, but its fusibility is lowered. If more than a certain proportion of tin be added, thin and very fluid solders are obtained of grayish-white color, and very brittle—indeed, so brittle that the soldering joints are apt to open if the object is bent. Because too great an addition of tin is injurious, the utmost caution must be exercised. If very refractory metals are to be soldered, brass alone can be used. In some cases, a solder can be produced merely by melting brass and adding copper. The following hard solders have been practically tested and found of value.

#### YELLOW HARD SOLDERS:

##### Applebaum's Compositions.—

I.—Copper.....	58	parts
Zinc.....	42	parts
II.—Sheet brass...	85.42	parts
Zinc.....	13.58	parts

##### Karmarsch's Composition.—

III.—Brass.....	7	parts
Zinc.....	1	part
IV.—Zinc.....	49	parts
Copper.....	44	parts
Tin.....	4	parts
Lead.....	2	parts

##### Precht's Composition.—

V.—Copper.....	53.3	parts
Zinc.....	43.1	parts
Tin.....	1.3	parts
Lead.....	0.3	parts

All these hard-solder compositions

have the fine yellow color of brass, are very hard, and can be fused only at high temperatures. They are well adapted for all kinds of iron, steel, copper, and bronze.

Solders which fuse at somewhat lower temperatures and, therefore, well adapted for the working of brass, are the following:

VI.—Sheet brass...	81.12	parts
Zinc.....	18.88	parts

VII.—Copper.....	54.08	parts
Zinc.....	45.29	parts

VIII.—Brass.....	3 to 4	parts
Zinc.....	1	part

A solder which is valuable because it can be wrought with the hammer, rolled out, or drawn into wire, and because it is tough and ductile, is the following:

IX.—Brass.....	78.26	parts
Zinc.....	17.41	parts
Silver.....	4.33	parts

#### Fusible White Solder.—

X.—Copper.....	57.4	parts
Zinc.....	28	parts
Tin.....	14.6	parts

#### Easily Fusible Solders.—

XI.—Brass.....	5	parts
Zinc.....	2.5	parts

XII.—Brass.....	5	parts
Zinc.....	5	parts

#### Semi-White Hard Solders.—

XIII.—Copper.....	53.3	parts
Zinc.....	46.7	parts

XIV.—Brass.....	12	parts
Zinc.....	4 to 7	parts
Tin.....	1	part

XV.—Brass.....	22	parts
Zinc.....	10	parts
Tin.....	1	part

XVI.—Copper.....	44	parts
Zinc.....	49	parts
Tin.....	3.20	parts
Lead.....	1.29	parts

Formulas XIII and XVI are fairly fusible.

#### White Hard Solders.—

XVII.—Brass.....	20	parts
Zinc.....	1	part
Tin.....	4	parts

XVIII.—Copper.....	58	parts
Zinc.....	17	parts
Tin.....	15	parts

XIX.—Brass.....	11	parts
Zinc.....	1	part
Tin.....	2	parts



XX.—Brass.....	6	parts
Zinc.....	4	parts
Tin.....	10	parts

XXI.—Copper.....	57.44	parts
Zinc.....	27.98	parts
Tin.....	14.58	parts

For Brass Tubes.—I.—Copper, 100 parts; lead, 25 parts.

II.—A very strong solder for soldering brass tubes to be drawn, etc., is composed of 18 parts brass, 4 parts zinc, and 1 part fine silver.

For Fastening Brass to Tin.—To 20 parts of fine, reduced copper, add sufficient sulphuric acid to make a stiff paste. To this add 70 parts of metallic mercury, and work in, at the same time applying heat until the mass assumes a wax-like consistency. Warm or heat the plates to be united, to about the same temperature, apply the mixture, hot, to each, then press together, and let cool.

#### COPPER SOLDERS.

The copper solders which are used for soldering copper as well as bronze are mixtures of copper and lead. By increasing the quantity of lead the fusibility is increased, but the mixture departs from the color and toughness of copper. The most commonly employed copper solder is the following:

I.—Copper.....	5	parts
Lead.....	1	part

II.—Copper.....	80	parts
Lead.....	15	parts
Tin.....	5	parts

For Red Copper.—I.—Copper, 3 parts; zinc, 1 part.

II.—Copper, 7 parts; zinc, 3 parts; tin, 2 parts.

#### FATS FOR SOLDERING.

I.—Soldering fat or grease is commonly a mixture of rosin and tallow with the addition of a small quantity of sal ammoniac. It is particularly adapted to the soldering of tinned ware, because it is easily wiped off the surface after the joint is made, whereas if rosin were used alone, the scraping away might remove some of the tin and spoil the object.

II.—The following is a well-tried recipe for a soldering grease: In a pot of sufficient size and over a slow fire melt together 500 parts of olive oil and 400 parts of tallow; then stir in slowly 250 parts of rosin in powder, and let the whole boil up once. Now let it cool

down, and add 125 parts of saturated solution of sal ammoniac, stirring the while. When cold, this preparation will be ready for use.

#### FLUIDS FOR SOLDERING.

I.—To the ordinary zinc chloride, prepared by digesting chips of zinc in strong hydrochloric acid to saturation, add  $\frac{1}{2}$  spirits of sal ammoniac and  $\frac{1}{2}$  part rain water, and filter the mixture. This soldering liquid is especially adapted to the soft soldering of iron and steel, because it does not make rust spots.

To solder zinc, the zinc chloride may be used without any spirit sal ammoniac.

II.—Mix phosphoric acid with strong spirits of wine in the following proportions:

Phosphoric acid solution.....	1	quart
Spirits of wine (80 per cent).....	1½	quarts

More or less of the spirits of wine is used depending upon the concentration of the phosphoric acid solution. When this soldering liquid is applied to the metal to be soldered, the phosphoric acid immediately dissolves the oxide. The hot soldering iron vaporizes the spirits of wine very quickly and causes the oxide released by the phosphoric acid to form a glazed mass with the surplus phosphoric acid, which mass can be easily removed.

III.—Dissolve in hydrochloric acid: Zinc, 50 parts (by weight); sal ammoniac, 50 parts.

IV.—Hydrochloric acid, 600 parts (by weight); sal ammoniac, 100 parts. Put zinc chips into the acid to saturation, next add the sal ammoniac. Filter when dissolved and preserve in flasks.

V.—Eight hundred parts of water with 100 parts of lactic acid and 100 parts of glycerine. This dispenses with the use of chloride of zinc.

Acid-Free Soldering Fluid.—I.—Five parts of zinc chloride dissolved in 25 parts of boiling water. Or, 20 parts of zinc chloride, 10 parts of ammonia chloride, dissolved in 100 parts of boiling water and put into glass carboys.

II.—Chloride zinc.....	1	drachm
Alcohol.....	1	ounce

Substitute for Soldering Fluid.—As a substitute for the customary soldering fluid and soldering mediums an ammonia soap is recommended, which is obtained by the mixture of a finely powdered rosin with strong ammonia solution. Of this soap only the finely divided



rosin remains on the soldered place after the soldering. This soldering process is well adapted for soldering together copper wires for electrical conduits, since the rosin at the same time serves as an insulator.

#### FLUXES FOR SOLDERING.

The fluxes generally used in the soft-soldering of metals are powdered rosin or a solution of chloride of zinc, alone or combined with sal ammoniac. A neutral soldering liquid can be prepared by mixing 27 parts neutral zinc chloride, 11 parts sal ammoniac, and 62 parts water; or, 1 part sugar of milk, 1 part glycerine, and 8 parts water.

A soldering fat for tin-plate, preferable to ordinary rosin, as it can be more easily removed after soldering, is prepared as follows: One hundred and fifty parts beef tallow, 250 parts rosin, and 150 parts olive oil are melted together in a crucible and well stirred, 50 parts powdered sal ammoniac dissolved in as little water as possible being added.

Soldering fat for iron is composed of 50 parts olive oil and 50 parts powdered sal ammoniac. Soldering fat for aluminum is made by melting together equal parts of rosin and tallow, half the quantity of zinc chloride being added to the mixture.

Soldering paste consists of neutral soldering liquid thickened with starch paste. This paste must be applied more lightly than the soldering liquid.

Soldering salt is prepared by mixing equal parts of neutral zinc chloride, free from iron, and powdered sal ammoniac. When required for use, 1 part of the salt should be dissolved in 3 or 4 parts water.

Borax is the flux most frequently used for hard-soldering; it should be applied to the soldering seam either dry or stirred to a paste with water. It is advisable to use calcined borax, i. e., borax from which the water of crystallization has been driven out by heat, as it does not become so inflated as ordinary borax. Borax dissolves the metallic oxides forming on the joint.

Finely powdered cryolite, or a mixture of 2 parts powdered cryolite and 1 part phosphoric acid, is also used for hard-soldering copper and copper alloys.

Muller's hard-soldering liquid consists of equal parts of phosphoric acid and alcohol (80 per cent).

A mixture of equal parts of cryolite and barium chloride is used as a flux in hard-soldering aluminum bronze.

A very good dry-soldering preparation consists of two vials, one of which is filled

with zinc chloride, and the other with ammonium chloride. To use, dissolve a little of each salt in water, apply the ammonium chloride to the object to be soldered and heat the latter until it begins to give off vapor of ammonium, then apply the other, and immediately thereafter the solder, maintaining the heat in the meantime. This answers for very soft solder. For a harder solder dissolve the zinc in a very small portion of the ammonium chloride solution (from  $\frac{1}{4}$  to  $\frac{1}{2}$  pint).

When steel is to be soldered on steel, or iron on steel, it is necessary to remove every trace of oxide of iron between the surfaces in contact. Melt in an earthen vessel: Borax, 3 parts; colophony, 2 parts; pulverized glass, 3 parts; steel filings, 2 parts; carbonate of potash, 1 part; hard soap, powdered, 1 part. Flow the melted mass on a cold plate of sheet iron, and after cooling break up the pieces and pulverize them. This powder is thrown on the surfaces a few minutes before the pieces to be soldered are brought together. The borax and glass contained in the composition dissolve, and consequently liquefy all of the impurities, which, if they were shut up between the pieces soldered, might form scales, at times dangerous, or interfering with the resistance of the piece.

To prepare rosin for soldering bright tin, mix  $1\frac{1}{2}$  pounds of olive oil,  $1\frac{1}{2}$  pounds of tallow, and 12 ounces of pulverized rosin, and let them boil up. When this mixture has become cool, add  $1\frac{1}{2}$  pints of water saturated with pulverized sal ammoniac, stirring constantly.

#### GAS SOLDERING.

The soldering of small metallic articles where the production is a wholesale one, is almost exclusively done by the use of gas, a pointed flame being produced by air pressure. The air pressure is obtained by the workman who does the soldering setting in motion a treadle with his foot, which, resting on rubber bellows, drives by pressure on the same the aspirated air into wind bellows. From here it is sent into the soldering pipe, where it is connected with the gas and a pointed flame is produced. In order to obtain a rather uniform heat the workman has to tread continually, which, however, renders it almost impossible to hold the article to be soldered steady, although this is necessary if the work is to proceed quickly. Hence, absolutely skillful and expensive hands are required, on whom the employer is often entirely dependent. To improve



this method of soldering and obviate its drawbacks, the soldering may be conducted with good success in the following manner: For the production of the air current a small ventilator is set up. The wind is conducted through two main conduits to the work tables. Four or six tables may, for instance, be placed together, the wind and the gas pipe ending in the center. The gas is admitted as formerly, the wind is conducted into wind bellows by means of joint and hose to obtain a constant pressure and from here into the soldering pipe. In this manner any desired flame may be produced, the workman operates quietly and without exertion, which admits of employing youthful hands and consequently of a saving in wages. The equipment is considerably cheaper, since the rubber bellows under the treadle are done away with.

#### GERMAN-SILVER SOLDERS.

Because of its peculiar composition German-silver solder is related to the ordinary hard solders. Just as hard solders may be regarded as varieties of brass to which zinc has been added, German-silver solders may be regarded as German silver to which zinc has been added. The German-silver solder becomes more easily fused with an increase in zinc, and vice versa. If the quantity of zinc be increased beyond a certain proportion, the resultant solder becomes too brittle. German-silver solders are characterized by remarkable strength, and are therefore used not only in soldering German silver, but in many cases where special strength is required. As German silver can be made of the color of steel, it is frequently used for soldering fine steel articles.

Solder for ordinary German silver can be made of 1,000 parts German-silver chips, 125 parts sheet-brass chips, 142 parts zinc, and 33 parts tin; or, of 8 parts German silver and 2 to 3 parts zinc.

#### Soft German-Silver Solder.—

I.—Copper..... 4.5 parts  
Zinc..... 7 parts  
Nickel..... 1 part

II.—Copper..... 35 parts  
Zinc..... 56.5 parts  
Nickel..... 8.5 parts

III.—German silver..... 5 parts  
Zinc..... 5 parts

Compositions I and II have analogous properties. In composition III "German silver" is to be considered as a

mixture of copper, zinc, and nickel, for which reason it is necessary to know the exact composition of the German silver to be used. Otherwise it is advisable to experiment first with small quantities in order to ascertain how much zinc is to be added. The proper proportion of German silver to zinc is reached when the mixture reveals a brilliancy and condition which renders it possible to barely pulverize it while hot. A small quantity when brought in contact with the soldering iron should just fuse.

#### Hard German-Silver or Steel Solder.—

I.—Copper..... 35 parts  
Zinc..... 56.5 parts  
Nickel..... 9.5 parts

II.—Copper..... 38 parts  
Zinc..... 50 parts  
Nickel..... 12 parts

Composition I requires a fairly high temperature in order to be melted. Composition II requires a blow pipe.

#### GOLD SOLDERS:

Hard Solder for Gold.—The hard solder or gold solder which the jeweler frequently requires for the execution of various works, not only serves for soldering gold ware, but is also often employed for soldering fine steel goods, such as spectacles, etc. Fine gold is only used for soldering articles of platinum. The stronger the alloy of the gold, the more fusible must be the solder. Generally the gold solder is a composition of gold, silver, and copper. If it is to be very easily fusible, a little zinc may be added, but, on the other hand, even the copper is sometimes left out and a mixture consisting only of gold and silver (e. g., equal parts of both) is used. The shade of the solder also requires attention, which must be regulated by varying proportions of silver and copper, so that it may be as nearly as possible the same as that of the gold to be soldered.

I.—For 24-carat gold: Twenty-two parts gold (24 carat), 2 parts silver, and 1 part copper; refractory.

II.—For 18-carat gold: Nine parts gold (18 carat), 2 parts silver, and 1 part copper; refractory.

III.—For 16-carat gold: Twenty-four parts gold (16 carat), 10 parts silver, and 8 parts copper; refractory.

IV.—For 14-carat gold: Three parts gold (14 carat), 2 parts silver, and 1 part copper; more fusible.

V.—Gold solder for alloys containing smaller quantities of gold is composed



of 8 parts gold, 10.5 parts silver, and 5.5 parts copper, or,

VI.—Ten parts gold (13.5 carat), 5 parts silver, and 1 part zinc.

VII.—The following easily fusible solder is used for ordinary gold articles: Two parts gold, 9 parts silver, 1 part copper, and 1 part zinc. Articles soldered with this solder cannot be subjected to the usual process of coloring the gold, as the solder would become black.

VIII.—A refractory enamel solder for articles made of 20-carat and finer gold, which can bear the high temperature required in enameling, consists of 37 parts gold and 9 parts silver, or 16 parts gold (18 carat), 3 parts silver, and 1 part copper.

Which of these compositions should be employed depends upon the degree of the fusibility of the enamel to be applied. If it is very difficult of fusion only the first named can be used; otherwise it may happen that during the melting on of the enamel the soldering spots are so strongly heated that the solder itself melts. For ordinary articles, as a rule, only readily fusible enamels are employed, and consequently the readily fusible enameling solder may here be made use of. Soldering with the latter is readily accomplished with the aid of the soldering pipe. Although the more hardly fusible gold solders may also be melted by the use of the ordinary soldering pipe, the employment of a special small blowing apparatus is recommended on account of the resulting ease and rapidity of the work.

#### SOLDERS FOR GLASS.

I.—Melt tin, and add to the melted mass enough copper, with constant stirring, until the melted metal consists of 95 per cent of tin and 5 per cent of copper. In order to render the mixture more or less hard, add  $\frac{1}{2}$  to 1 per cent of zinc or lead.

II.—A compound of tin (95 parts) and zinc (5 parts) melts at 392° F., and can then be firmly united to glass. An alloy of 90 parts of tin and 10 parts of aluminum melts at 734° F., adheres, like the preceding, to glass, and is equally brilliant. With either of these alloys glass may be soldered as easily as metal, in two ways. In one, heat the pieces of glass in a furnace and rub a stick of soldering alloy over their surfaces. The alloy will melt, and can be easily spread by means of a roll of paper or a slip of aluminum. Press the pieces firmly together, and keep so until cool. In the

other method a common soldering iron, or a rod of aluminum, is heated over a coal fire, a gas jet, or a flame supplied by petroleum. The hot iron is passed over the alloy and then over the pieces to be soldered, without the use of a solvent. Care should be taken that neither the soldering irons nor the glass be brought to a temperature above the melting point of the alloy, lest the latter should be oxidized, and prevented from adhering.

#### HARD SOLDERS.

Hard solders are distinguished as brass, German silver, copper, gold, silver, etc., according to the alloys used (see Brass Solders, Copper Solders, etc., for other hard solders).

The designation "hard solder" is used to distinguish it from the easily running and softer solder used by tin-smiths, and it applies solely to a composition that will not flow under a red heat. For the purposes of the jeweler solder may be classified according to its composition and purpose, into gold or silver solder, which means a solder consisting of an alloy of gold with silver, copper, tin, or zinc-like metal or an alloy of silver with copper, tin, or zinc-like metal. According to the uses, the solder is made hard or soft; thus in gold solders there is added a greater amount of silver, whereas for silver solders there is added more tin or zinc-like metal.

In the production of solder for the enameler's use, that is for combining gold with gold, gold with silver, or gold with copper, which must be enameled afterwards, it is necessary always to keep in mind that no solder can be used effectually that contains any tin, zinc, zinc alloys, or tin or zinc-like metals in any great quantities, since it is these very metals that contribute to the cracking of the enamel. Yet it is not possible to do without such an addition entirely, otherwise the solder would not flow under the melting point of the precious metals themselves and we should be unable to effect a union of the parts. It is therefore absolutely necessary to confine these additions to the lowest possible percentage, so that only a trace is apparent. Moreover, care must be taken to use for enameling purposes no base alloy, because the tenacity or durability of the compound will be affected thereby; in other words, it must come up to the standard.

In hard soldering with borax, direct, several obstacles are encountered that make the process somewhat difficult. In

the first place the salt forms great bubbles in contact with the soldering iron, and easily scales away from the surface of the parts to be soldered. Besides this, the parts must be carefully cleaned each time prior to applying the salt. All these difficulties vanish if instead of borax we use its component parts, boric acid and sodium carbonate. The heat of the soldering iron acting on these causes them to combine in such a way as to produce an excellent flux, free from the difficulties mentioned.

#### Composition of Various Hard Solders.

—Yellow solders for brass, bronze, copper, and iron:

I.—Sheet-brass chips, 5 parts, and zinc, 3 to 5 parts, easily fusible.

II.—Sheet brass chips, 3 parts, and zinc, 1 part; refractory.

III.—Sheet-brass chips, 7 parts, and zinc, 1 part; very refractory and firm.

Semi-white solders, containing tin and consequently harder:

I.—Sheet brass, 12 parts; zinc, 4 to 7 parts, and tin, 1 part.

II.—Copper, 16 parts; zinc, 16 parts, and tin, 1 part.

III.—Yellow solder, 20 to 30 parts, and tin, 1 part.

White solders:

I.—Sheet brass, 20 parts; zinc, 1 part, and tin, 4 parts.

II.—Copper, 3 parts; zinc, 1 part, and tin, 1 part.

To Hard-Solder Parts Formerly Soldered with Tin Solder.—To repair gold or silver articles which have been spoiled with tin solder proceed as follows: Heating the object carefully by means of a small spirit lamp, brush the tin off as much as possible with a chalk brush; place the article in a diluted solution of hydrochloric acid for about 8 to 10 hours, as required. If much tin remains, perhaps 12 hours may be necessary. Next withdraw it, rinse off and dry; whereupon it is carefully annealed and finally put in a pickle of dilute sulphuric acid, to remove the annealing film. When the article has been dipped, it may be hard soldered again.

#### SILVER SOLDERS.

Silver solder is cast in the form of ingots, which are hammered or rolled into thin sheets. From these small chips or "links," as they are called, are cut off. The melted solder can also be poured, when slightly cooled, into a dry iron mortar and pulverized while still warm. The

solder can also be filed and the filings used for soldering.

Silver solders are used not only for soldering silver objects, but also for soldering metals of which great resistance is expected. A distinction must be drawn between silver solder consisting either of copper and silver alone, and silver solder to which tin has been added.

#### Very Hard Silver Solder for Fine Silverware.—

I.—Copper..... 1 part  
Silver..... 4 parts  
Hard silver solder.

II.—Copper..... 1 part  
Silver..... 20 parts  
Brass..... 9 parts

III.—Copper..... 2 parts  
Silver..... 28 parts  
Brass..... 10 parts  
Soft silver solder.

IV.—Silver..... 2 parts  
Brass..... 1 part

V.—Silver..... 3 parts  
Copper..... 2 parts  
Zinc..... 1 part

VI.—Silver..... 10 parts  
Brass..... 10 parts  
Tin..... 1 part

These solders are preferably to be employed for the completion of work begun with hard silver solders, defective parts alone being treated. For this purpose it is sometimes advisable to use copper-silver alloys mixed with zinc, as for example:

VII.—Silver..... 12 parts  
Copper..... 4 parts  
Zinc..... 1 part

VIII.—Silver..... 5 parts  
Brass..... 6 parts  
Zinc..... 2 parts

This last formula (VIII) is most commonly used for ordinary silverware.

#### Silver Solders for Soldering Iron, Steel, Cast Iron, and Copper.—

I.—Silver..... 10 parts  
Brass..... 10 parts

II.—Silver..... 20 parts  
Copper..... 30 parts  
Zinc..... 10 parts

III.—Silver..... 30 parts  
Copper..... 10 parts  
Tin..... 0.5 parts

IV.—Silver..... 60 parts  
Brass..... 60 parts  
Zinc..... 5 parts



In those solders in which brass is used care should be taken that none of the metals employed contains iron. Even an inappreciable amount of iron deleteriously affects the solder.

V.—Copper, 30 parts; zinc, 12.85 parts; silver, 57.15 parts.

VI.—Copper, 23.33 parts; zinc, 10 parts; silver, 66.67 parts.

VII.—Copper, 26.66 parts; zinc, 10 parts; silver, 63.34 parts.

VIII.—Silver, 66 parts; copper, 24 parts, and zinc, 10 parts. This very strong solder is frequently used for soldering silver articles, but can also be used for soldering other metals, such as brass, copper, iron, steel band-saw blades, etc.

IX.—Silver, 4 parts, and brass, 3 parts.

X.—A very refractory silver solder, which, unlike the silver solder containing zinc, is of great ductility and does not break when hammered, is composed of 3 parts silver and 1 part copper.

Soft Silver Solders.—I.—A soft silver solder for resoldering parts already soldered is made of silver, 3 parts; copper, 2 parts, and zinc, 1 part.

II.—Silver, 1 part, and brass, 1 part; or, silver, 7 parts; copper, 3 parts, and zinc, 2 parts.

III.—A readily fusible silver solder for ordinary work: Silver, 5 parts; copper, 6 parts, and zinc, 2 parts.

IV.—(Soft.) Copper, 14.75 parts; zinc, 8.20 parts; silver, 77.05 parts.

V.—Copper, 22.34 parts; zinc, 10.48 parts; silver, 67.18 parts.

VI.—Tin, 63 parts; lead, 37 parts.

French Solders for Silver.—I.—For fine silver work: Fine silver, 87 parts; brass, 13 parts.

II.—For work 792 fine: Fine silver, 83 parts; brass, 17 parts.

III.—For work 712 fine: Fine silver, 75 parts; brass, 25 parts.

IV.—For work 633 fine: Fine silver, 66 parts; brass, 34 parts.

V.—For work 572 fine: Fine silver, 55 parts; brass, 45 parts.

Solder for Silversmiths, etc.—Gold, 10 parts; silver, 55 parts; copper, 29 parts; zinc, 6 parts.

Hard Solder.—Silver, 60 parts; bronze, 39 parts; arsenic, 1 part.

Soft Solder.—Powdered copper, 30 parts; sulphate of zinc, 10 parts; mercury, 60 parts; sulphuric acid. Put

the copper and the zinc sulphate in a porcelain mortar, and then the sulphuric acid. Enough acid is required to cover the composition; next add the mercury while stirring constantly. When the amalgamation is effected, wash several times with hot water to remove the acid, then allow to cool. For use, it is sufficient to heat the amalgam until it takes the consistency of wax. Apply on the parts to be soldered and let cool.

Solder for Silver-Plated Work.—I.—Fine silver, 2 parts; bronze, 1 part.

II.—Silver, 68 parts; copper, 24 parts; zinc, 17 parts.

Solder for Silver Chains.—I.—Fine silver, 74 parts; copper, 24 parts; orpiment, 2 parts.

II.—Fine silver, 40 parts; orpiment, 20 parts; copper, 40 parts.

### SOFT SOLDERS:

See also Brass Solders, Copper Solders, Gold Solders.

I.—Fifty parts bismuth, 25 parts tin, and 25 parts lead. This mixture melts at 392° F.

II.—Fifty parts bismuth, 30 parts lead, and 20 parts tin. This will melt at 374° F.

III.—The solder that is used in soldering Britannia metal and block tin pipes is composed of 2 parts tin and 1 part lead. This melts in the blow-pipe flame at many degrees lower temperature than either tin or Britannia metal, and it is nearly of the same color. Care must be taken in mixing these solders to keep them well stirred when pouring into molds. Care should also be taken that the metal which melts at a higher temperature be melted first and then allowed to cool to the melting temperature of the next metal to be added, and so on. Articles to be soldered with these solders should be joined with a blow pipe to get the best results, but if a copper is used it must be drawn out to a long, thin point. For a flux use powdered rosin or sweet oil.

Tin solders for soldering lead, zinc, tin, tin-plate, also copper and brass when special strength is not required, are prepared as follows:

I.—Tin, 10 parts; lead, 4 parts; melting point, 356° F.

II.—Tin, 10 parts; lead, 5 parts; melting point, 365° F.

III.—Tin, 10 parts; lead, 6 parts; melting point, 374° F.

IV.—Tin, 10 parts; lead, 10 parts; melting point, 392° F.

V.—Tin, 10 parts; lead, 15 parts; melting point, 432° F.

VI.—Tin, 10 parts; lead, 20 parts; melting point, 464° F.

The last of the above mixtures is the cheapest, on account of the large quantity of lead.

Bismuth solder or pewterer's solder fusible at a low temperature is prepared by melting together:

I.—Tin, 2 parts; lead, 1 part; bismuth, 1 part; melting point, 266° F.

II.—Tin, 3 parts; lead, 4 parts; bismuth, 2 parts; melting point, 297° F.

III.—Tin, 2 parts; lead, 2 parts; bismuth, 1 part; melting point, 320° F.

### STEEL SOLDERING.

Dissolve scraps of cast steel in as small a quantity as possible of nitric acid, add finely pulverized borax and stir vigorously until a fluid paste is formed, then dilute by means of sal ammoniac and put in a bottle. When soldering is to be done, apply a thin layer of the solution to the two parts to be soldered, and when these have been carried to ordinary redness, and the mass is consequently plastic, beat lightly on the anvil with a flat hammer. This recipe is useful for cases when the steel is not to be soldered at an elevation of temperature to the bright red.

To Solder a Piece of Hardened Steel.—To hard-solder a piece of hardened steel such as index (regulator), stop spring (in the part which is not elastic), click, etc., take a very flat charcoal if the piece is difficult to attach; hard-solder and as soon as the soldering has been done, plunge the piece into oil. All that remains to be done is to blue it again and to polish.

Soldering Powder for Steel.—Melt in an earthen pot 3 parts of borax, 2 of colophony, 1 of potassium carbonate, as much powdered hard soap, to which must be added 3 parts of finely powdered glass and 2 parts of steel filings. The melted mass is run out upon a cold plate of sheet iron, and when it is completely chilled it is broken into small bits or finely powdered. To solder, it is necessary to sprinkle the powder on the surfaces to be joined several minutes before bringing them together.

Soldering Solution for Steel.—A soldering solution for steel that will not rust

or blacken the work is made of 6 ounces alcohol, 2 ounces glycerine, and 1 ounce oxide of zinc.

### PLATINUM SOLDERS.

There are many platinum solders in existence, but the main principle to be borne in mind in jewelry work is that the soldering seam should be as little perceptible as possible; the solder, therefore, should have the same color as the alloy.

I.—A platinum solder which meets these requirements very satisfactorily is composed of 9 parts gold and 1 part palladium; or, 8 parts gold and 2 parts palladium.

II.—The following is a readily fusible platinum solder: Fine silver, 1.555 parts, and pure platinum, 0.583 parts. This melts easily in the ordinary draught furnace, as well as before the soldering pipe on a piece of charcoal. Of similar action is a solder of the following composition, which is very useful for places not exposed to the view:

III.—Fine gold, 1.555 parts; fine silver, 0.65 parts; and pure copper, 0.324 parts.

### SOLDER FOR IRON:

See also under Silver Solders.

Copper, 67 parts; zinc, 33 parts; or, copper, 60 parts; zinc, 40 parts.

### TIN SOLDERS:

See also Soft Solders.

Gold jewelry which has been rendered unsightly by tin solder may be freed from tin entirely by dipping the article for a few minutes into the following solution and then brushing off the tin: Pulverize 2 parts of green vitriol and 1 part of saltpeter and boil in a cast-iron pot with 10 parts of water until the larger part of the latter has evaporated. The crystals forming upon cooling are dissolved in hydrochloric acid (8 parts of hydrochloric acid to 1 part of crystals). If the articles in question have to be left in the liquid for some time, it is well to dilute it with 3 or 4 parts of water. The tin solder is dissolved by this solution without attacking or damaging the article in the least.

### VARIOUS RECIPES FOR SOLDERING:

To Conceal Soldering.—Visible soldering may be obviated by the following methods: For copper goods a concentrated solution of blue vitriol is prepared and applied to the places by means of an iron rod or iron wire. The thickness of



the layer may be increased by a repetition of the process. In order to give the places thus coppered the appearance of the others, use a saturated solution of zinc vitriol, 1 part, and blue vitriol, 2 parts, and finish rubbing with a piece of zinc. By sprinkling on gold powder and subsequently polishing, the color is rendered deeper. In the case of gold articles the places are first coppered over, then covered with a thin layer of fish glue, after which bronze filings are thrown on. When the glue is dry rub off quickly to produce a fine polish. The places can, of course, also be electro-gilt, whereby a greater uniformity of the shade is obtained. In silver objects, the soldering seams, etc., are likewise coppered in the above-described manner; next they are rubbed with a brush dipped into silver powder and freshly polished.

**Solder for Articles which will not Bear a High Temperature.**—Take powdered copper, the precipitate of a solution of the sulphate by means of zinc, and mix it with concentrated sulphuric acid. According to the degree of hardness required, take from 20 to 30 or 36 parts of copper. Add, while constantly shaking, 70 parts of quicksilver, and when the amalgam is complete, wash with warm water to remove the acid; then allow it to cool. In 10 or 12 hours the composition will be hard enough to scratch tin. For use, warm it until it reaches the consistency of wax, and spread it where needed. When cold it will adhere with great tenacity.

#### **Soldering a Ring Containing a Jewel.**

**I.**—Fill a small crucible with wet sand and bury the part with the jewel in the sand. Now solder with soft gold solder, holding the crucible in the hand. The stone will remain uninjured.

**II.**—Take tissue paper, tear it into strips about 3 inches in width, and make them into ropes; wet them thoroughly and wrap the stone in them, passing around the stone and through the ring until the center of the latter is slightly more than half filled with paper, closely wound around. Now fix on charcoal, permitting the stone to protrude over the edge of the charcoal, and solder rapidly. The paper will not only protect the stone, but also prevent oxidation of the portion of the ring which is covered.

**Soldering without Heat.**—For soldering objects without heating, take a large copper wire filed to a point; dip into soldering water and rub the parts to be soldered. Then heat the copper wire

and apply the solder, which melts on contact. It may then be applied to the desired spot without heating the object.

#### **COLD SOLDERING:**

See also Adhesives and Cements.

For soldering articles which cannot stand a high temperature, the following process may be employed:

**I.**—Take powdered copper precipitated from a solution of sulphate by means of zinc and mix it in a cast-iron or porcelain mortar with concentrated sulphuric acid. The number of parts of copper varies according to the degree of hardness which it is wished to obtain. Next add, stirring constantly, 70 parts of mercury, and when the amalgam is finished, allow to cool. At the end of 10 to 12 hours the composition is sufficiently hard. For use, heat until it acquires the consistency of wax. Apply to the surface. When cool it will adhere with great tenacity.

**II.**—Crush and mix 6 parts of sulphur, 6 parts of white lead, and 1 part of borax. Make a rather thick cement of this powder by triturating it with sulphuric acid. The paste is spread on the surfaces to be welded, and the articles pressed firmly together. In 6 or 7 days the soldering is so strong that the two pieces cannot be separated, even by striking them with a hammer.

**Cast-Iron Soldering.**—A new process consists in decarbonizing the surfaces of the cast iron to be soldered, the molten hard solder being at the same time brought into contact with the red-hot metallic surfaces. The admission of air, however, should be carefully guarded against. First pickle the surfaces of the pieces to be soldered, as usual, with acid and fasten the two pieces together. The place to be soldered is now covered with a metallic oxygen compound and any one of the customary fluxes and heated until red hot. The preparation best suited for this purpose is a paste made by intimately mingling together cuprous oxide and borax. The latter melts in soldering and protects the pickled surfaces as well as the cuprous oxide from oxidation through the action of the air. During the heating the cuprous oxide imparts its oxygen to the carbon contained in the cast iron and burns it. Metallic copper separates in fine subdivision. Now apply hard solder to the place to be united, which in melting forms an alloy with the eliminated copper, the alloy combining with the decarburized surfaces of the cast iron.



**Soldering Block.**—This name is given to a very useful support for hard soldering and can be readily made. The ingredients are: Charcoal, asbestos, and plaster of Paris. These are powdered in equal parts, made into a thick paste with water, and poured into a suitable mold. Thus a sort of thick plate is obtained. When this mass has dried it is removed from the mold and a very thin cork plate is affixed on one surface by means of thin glue. The mission of this plate is to receive the points of the wire clamps with which the articles to be soldered are attached to the soldering block, the asbestos not affording sufficient hold for them.

#### SOLDERS FOR JEWELERS:

See Jewelers' Formulas.

#### SOLDER FROM GOLD, TO REMOVE:

See Gold.

#### SOLDERING PASTE.

The semi-liquid mass termed soldering paste is produced by mixing zinc chloride solution or that of ammoniac zinc chloride with starch paste. For preparing this composition, ordinary potato starch is made with water into a milky liquid, the latter is heated to a boil with constant stirring, and enough of this mass, which becomes gelatinous after cooling, is added to the above-mentioned solutions as to cause a liquid resembling thin syrup to result. The use of all zinc preparations for soldering presents the drawback that vapors of a strongly acid odor are generated by the heat of the soldering iron, but this evil is offset by the extraordinary convenience afforded when working with these preparations. It is not necessary to subject the places to be soldered to any special cleaning or preparation. All that is required is to coat them with the soldering medium, to apply the solder to the seam, etc., and to wipe the places with a sponge or moistened rag after the solder has cooled. Since the solder adheres readily with the use of these substances, a skillful workman can soon reach such perfection that he has no, or very little, subsequent polishing to do on the soldering seams.

**Soft Soldering Paste.**—Small articles of any metals that would be very delicate to solder with a stick of solder, especially where parts fit into another and only require a little solder to hold them together, can best be joined with a soldering paste. This paste contains the solder and flux combined, and is easily applied to seams, or a little applied be-

fore the parts are put together. The soldering flame will cause the tin in the paste to amalgamate quickly. The paste is made out of starch paste mixed with a solution of chloride of tin to the consistency of syrup.

#### SOOT REMOVERS.

To clean out stovepipes and furnace flues of an accumulation of soot without trouble or muss, is entirely possible by the use of common materials. Metallic zinc is one of these soot-removing agents, and it can be used in any form, such as old tops from fruit jars, old washboard coverings, dry-cell cases, and the like. In the case of the last-named, a particularly pleasing effect is obtained when an old dry cell is dropped into the flames of an open fire, which produces a delightful play of colored light. A handful or two of salt thrown into the furnace is also good for removing accumulations of soot.

#### SPECULUM METAL:

See Alloys.

#### SPICES, ADULTERATED:

See Foods.

#### SPICES FOR FLAVORING:

See Condiments.

### Spirit

#### INDUSTRIAL AND POTABLE ALCOHOL: SOURCES AND MANUFACTURE.

*Abstract of a Farmers' Bulletin prepared for the United States Department of Agriculture by Dr. Harvey W. Wiley.*

The term "industrial alcohol," or spirit, is used for brevity, and also because it differentiates sharply between alcohol used for beverages or for medicine and alcohol used for technical purposes in the arts.

**Alcohol Defined.**—The term "alcohol" as here used and as generally used means that particular product which is obtained by the fermentation of a sugar, or a starch converted into sugar, and which, from a chemical point of view, is a compound of the hypothetical substance "ethyl" with water, or with that part of water remaining after the separation of one of the atoms of hydrogen. This is a rather technical expression, but it is very difficult, without using technical language, to give a definition of alcohol from the chemical point of view. There are three elementary substances represented in alcohol: Carbon, the chemical symbol of which is C; hydrogen, symbol



H; and oxygen, symbol O. These atoms are put together to form common alcohol, or, as it is called, ethyl alcohol, in which preparation 2 atoms of carbon and 5 atoms of hydrogen form the hypothetical substance "ethyl," and 1 atom of oxygen and 1 atom of hydrogen form the hydroxyl derived from water. The chemical symbol of alcohol therefore is  $C_2H_5.OH$ . Absolutely pure ethyl alcohol is made only with great difficulty, and the purest commercial forms still have associated with them traces of other volatile products formed at the time of the distillation, chief among which is that group of alcohols to which the name "fused oil" is applied. So far as industrial purposes are concerned, however, ethyl alcohol is the only component of any consequence, just as in regard to the character of beverages the ethyl alcohol is the component of least consequence.

**Sources of Potable Alcohol.**—The raw materials from which alcohol is made consist of those crops which contain sugar, starch, gum, and cellulose (woody fiber) capable of being easily converted into a fermentable sugar. Alcohol as such is not used as a beverage. The alcohol occurring in distilled beverages is principally derived from Indian corn, rye, barley, and molasses. Alcohol is also produced for drinking purposes from fermented fruit juices such as the juice of grapes, apples, peaches, etc. In the production of alcoholic beverages a careful selection of the materials is required in order that the desired character of drink may be secured. For instance, in the production of rum, the molasses derived from the manufacture of sugar from sugar cane is the principal raw material. In the fermentation of molasses a particular product is formed which by distillation gives the alcohol compound possessing the aroma and flavor of rum. In the making of brandy, only sound wine can be used as the raw material, and this sound wine, when subjected to distillation, gives a product containing the same kind of alcohol as that found in rum, but associated with the products of fermentation which give to the distillate a character entirely distinct and separate from that of rum. Again, when barley malt or a mixture of barley malt and rye is properly mashed, fermented, and subjected to distillation, a product is obtained which, when properly concentrated and aged, becomes potable malt or rye whisky. In a similar manner, if Indian corn and bar-

ley malt are properly mashed, with a small portion of rye, the mash fermented and subjected to distillation, and the distillate properly prepared and aged, the product is known as Bourbon whisky. Thus, every kind of alcoholic beverage gets its real character, taste, and aroma, not from the alcohol which it contains but from the products of fermentation which are obtained at the same time the alcohol is made and which are carried over with the alcohol at the time of distillation.

**Agricultural Sources of Industrial Alcohol.**—The chief alcohol-yielding material produced in farm crops is starch, the second important material is sugar, and the third and least important raw material is cellulose, or woody fiber. The quantity of alcohol produced from cellulose is so small as to be of no importance at the present time, and therefore this source of alcohol will only be discussed under the headings "Utilization of Waste Material or By-Products" and "Wood Pulp and Sawdust."

**Starch-Producing Plants.**—Starch is a compound which, from the chemical point of view, belongs to the class known as carbohydrates, that is, compounds in which the element carbon is associated by a chemical union with water. Starch is therefore a compound made of carbon, hydrogen, and oxygen, existing in the proportion of 2 atoms of hydrogen to 1 atom of oxygen. Each molecule of starch contains at least 6 atoms of carbon, 10 atoms of hydrogen, and 5 atoms of oxygen. The simplest expression for starch is therefore  $C_6H_{10}O_5$ . Inasmuch as this is the simplest expression for what the chemist knows as a molecule of starch, and it is very probable that very many, perhaps a hundred or more, of these molecules exist together, the proper expression for starch from a chemical point of view would be  $(C_6H_{10}O_5)_x$ .

The principal starch-producing plants are the cereals, the potato, and cassava. With the potato may be classed, though not botanically related thereto, the sweet potato and the yam. Among cereals rice has the largest percentage of starch and oats the smallest. The potato, as grown for the table, has an average content of about 15 per cent of starch. When a potato is grown specifically for the production of alcohol it contains a larger quantity, or nearly 20 per cent. Cassava contains a larger percentage of starch than the potato, varying from 20 to 30 per cent.

**Sugar-Producing Plants.**—*Sugar cane,*



etc. While sugar is present in some degree in all vegetable growths, there are some plants which produce it in larger quantities than are required for immediate needs, and this sugar is stored in some part of the plant. Two plants are preëminently known for their richness in sugar, namely, the sugar cane and the sugar beet. In Louisiana the sugar canes contain from 9 to 14 per cent of sugar, and tropical canes contain a still larger amount.

The juices of the sugar beet contain from 12 to 18 per cent of sugar. There are other plants which produce large quantities of sugar, but which are less available for sugar-making purposes than those just mentioned. Among these, the sorghum must be first mentioned, containing in the stalk at the time the seed is just mature and the starch hardened from 9 to 15 per cent of sugar. Sorghum seed will also yield as much alcohol as equal weights of Indian corn. The juices of the stalks of Indian corn contain at the time the grain is hardening and for some time thereafter large quantities of sugar, varying from 8 to 15 per cent.

In the case of the sorghum and the Indian-corn stalk a large part of the sugar present is not cane sugar or sucrose as it is commonly known, but the invert sugar derived therefrom. For the purposes of making alcohol the invert sugar is even more suitable than cane sugar. Many other plants contain notable quantities of sugar, but, with the exception of fruits, discussed under the following caption, not in sufficient quantities to be able to compete with those just mentioned for making either sugar or alcohol.

Cane sugar is not directly susceptible to fermentation. Chemically considered, it has the formula expressed by the symbols:  $C_{12}H_{22}O_{11}$ . When cane sugar having the above composition becomes inverted, it is due to a process known as hydrolysis, which consists in the molecule of cane sugar taking up 1 molecule of water and splitting off into 2 molecules of sugar having the same formula but different physical and chemical properties. Thus the process may be represented as follows:  $C_{12}H_{22}O_{11}$  (cane sugar) +  $H_2O$  (water) =  $C_6H_{12}O_6$  (dextrose) +  $C_6H_{12}O_6$  (levulose). These two sugars (dextrose and levulose) taken together are known as invert sugar and are directly susceptible to fermentation. All cane sugar assumes the form of invert sugar before it becomes fermented.

**Fruits.**—Nearly all fruit juices are rich in sugar, varying in content from 5

to 30 per cent. The sugar in fruits is composed of both cane sugar and its invert products (dextrose and levulose), in some fruits principally the latter. Of the common fruits the grape yields the largest percentage of sugar. The normal grape used for wine making contains from 16 to 30 per cent of sugar, the usual amount being about 20 per cent. Fruit juices are not usually employed in any country for making industrial alcohol, because of their very much greater value for the production of beverages.

**Composition and Yield of Alcohol-Producing Crops.**—The weight of alcohol that may be produced from a given crop is estimated at a little less than one-half of the amount of fermentable substance present, it being understood that the fermentable substance is expressed in terms of sugar. Pasteur was the first to point out the fact that when sugar was fermented it yielded theoretically a little over one-half of its weight of alcohol. It must be remembered, however, that in the production of alcohol a process of hydrolysis is taking place which adds a certain quantity of alcohol to the products which are formed. For this reason 100 parts of sugar yield more than 100 parts of fermentable products. The distribution of the weights produced, as theoretically calculated by Pasteur, is as follows:

One hundred parts of sugar yield the following quantities of the products of fermentation:

Alcohol.....	51.10 parts
Carbonic acid.....	49.20 parts
Glycerine.....	3.40 parts
Organic acids, chiefly succinic.....	.65 parts
Ethers, aldehydes, fural, fat, etc.....	1.30 parts

Total weight fermentation products produced... 105.65 parts

**Artichokes.**—The artichoke has been highly recommended for the manufacture of alcohol. The fermentable material in the artichoke is neither starch nor sugar, but consists of a mixture of a number of carbohydrates of which inulin and levulin are the principal constituents. When these carbohydrate materials are hydrolyzed into sugars they produce levulose instead of dextrose. The levulose is equally as valuable as dextrose for the production of alcohol. Artichokes may be harvested either in the autumn or in the spring. As they keep well during the winter, and in a few places



may be kept in hot weather, they form a raw material which can be stored for a long period and still be valuable for fermentation purposes.

Under the term "inulin" are included all the fermentable carbohydrates. The above data show, in round numbers, 17 per cent of fermentable matter. Theoretically, therefore, 100 pounds of artichokes would yield approximately  $8\frac{1}{2}$  pounds of industrial alcohol, or about  $1\frac{1}{4}$  gallons.

*Bananas.*—The banana is a crop which grows in luxurious abundance in tropical countries, especially Guatemala and Nicaragua. The fruit contains large quantities of starch and sugar suitable for alcohol making. From 20 to 25 per cent of the weight of the banana consists of fermentable material. It is evident that in the countries where the banana grows in such luxuriance it would be a cheap source of industrial alcohol.

*Barley and the Manufacture of Malt.*—A very important cereal in connection with the manufacture of alcohol is barley which is quite universally employed for making malt, the malt in its turn being used for the conversion of the starch of other cereals into sugar in their preparation for fermentation.

Malt is made by the sprouting of barley at a low temperature (from 50° to 60° F.) until the small roots are formed and the germ has grown to the length of  $\frac{1}{2}$  an inch or more. The best malts are made at a low temperature requiring from 10 to 14 days for the growth of the barley. The barley is moistened and spread upon a floor, usually of cement, to the depth of 1 foot or 18 inches. As the barley becomes warm by the process of germination, it is turned from time to time and the room is kept well ventilated and cool. It is better at this point in the manufacture of malt to keep the temperature below 60° F. After the sprouting has been continued as above noted for the proper length of time, the barley is transferred to a drier, where it is subjected to a low temperature at first and finally to a temperature not to exceed 140° or 158° F., until all the water is driven off, except 2 or 3 per cent. Great care must be exercised in drying the barley not to raise the temperature too high, lest the diastase which is formed be deprived of its active qualities. The malt has a sweetish taste, the principal portion of the starch having been converted into sugar, which is known chemically as "maltose." This sugar is, of course, utilized in the fermentation for the production of alcohol. Malt is

chiefly valuable, however, not because of the amount of alcohol that may be produced therefrom, but from the fact that in quantities of about 10 per cent it is capable of converting the starch of the whole of the unmalted grains, whatever their origin may be, into maltose, thus preparing the starch for fermentation. Barley is not itself used in this country as a source of industrial alcohol, but it is employed for producing the highest grades of whisky, made of pure barley malt, which, after fermentation, is distilled in a pot still, concentrated in another pot still to the proper strength, placed in wood, and stored for a number of years. Barley malt is too expensive a source of alcohol to justify its use for industrial purposes. It is, however, one of the cheapest and best methods of converting the starch of other cereals into sugar preparatory to fermentation.

Barley has, in round numbers, about 68 per cent of fermentable matter. The weight of a bushel of barley (48 pounds) multiplied by 0.68 gives 32 pounds of fermentable matter in a bushel of barley.

*Cassava.*—Cassava is grown over a large area of the South Atlantic and Gulf States of this country. Of all the substances which have been mentioned, except the cereals, cassava contains the largest amount of alcoholic or fermentable substances. The root, deprived of its outer envelope, contains a little over 30 per cent of starch, while the undetermined matter in the analyses is principally sugar. If this be added to the starch, it is seen that approximately 35 per cent of the fresh root is fermentable. This of course represents a very high grade of cassava, the ordinary roots containing very much less fermentable matter. If, however, it is assumed that the fermentable matter of cassava root will average 25 per cent, this amount is much greater than the average of the potato, or even of the sweet potato and the yam. Twenty-five per cent is undoubtedly a low average content of fermentable matter. In the dry root there is found nearly 72 per cent of starch and 17 per cent of extract, principally sugar. Assuming that 15 per cent of this is fermentable, and adding this to the 72 per cent, it is seen that 87 per cent of the dry matter of the cassava is fermentable. This appears to be a very high figure, but it doubtless represents almost exactly the conditions which exist. It would be perfectly safe to say, discounting any exceptional qualities of the samples examined, that 80 per cent of the dry matter of the cassava root is



capable of being converted into alcohol. It thus becomes in a dry state a source of alcohol almost as valuable, pound for pound, as rice.

Careful examinations, however, of actual conditions show that if 5 tons per acre of roots are obtained it is an average yield. In very many cases, where no fertilizer is used and where the roots are grown in the ordinary manner, the yield is far less than this, while with improved methods of agriculture it is greater. The bark of the root, has very little fermentable matter in it. If the whole root be considered, the percentage of starch is less than it would be for the peeled root. If cassava yields 4 tons, or 8,000 pounds, per acre and contains 25 per cent of fermentable matter, the total weight of fermentable matter is 2,000 pounds, yielding approximately 1,000 pounds of 95 per cent alcohol, or 143 gallons of 95 per cent alcohol per acre.

*Corn (Indian Corn or Maize).*—The crop which at the present time is the source of almost all of the alcohol made in the United States is Indian corn.

The fermentable matter in Indian corn—that is, the part which is capable of being converted into alcohol—amounts to nearly 70 per cent of the total weight, since the unfermentable cellulose and pentosans included in carbohydrates do not exceed 2 per cent. Inasmuch as a bushel of Indian corn weighs 56 pounds, the total weight of fermentable matter therein, in round numbers, is 39 pounds. The weight of the alcohol which is produced under the best conditions is little less than one-half of the fermentable matter. Therefore the total weight of alcohol which would be yielded by a bushel of average Indian corn would be, in round numbers, about 19 pounds. The weight of a gallon of 95 per cent alcohol is nearly 7 pounds. Hence 1 bushel of corn would produce 2.7 gallons.

If the average price of Indian corn be placed, in round numbers, at 40 cents a bushel, the cost of the raw material—that is, of the Indian corn—for manufacturing 95 per cent industrial alcohol is about 15 cents a gallon. To this must be added the cost of manufacture, storage, etc., which is perhaps as much more, making the estimated actual cost of industrial alcohol of 95 per cent strength made from Indian corn about 30 cents per gallon. If to this be added the profits of the manufacturer and dealer, it appears that under the conditions cited, industrial alcohol, untaxed, should be sold for about 40 cents per gallon.

*Potatoes.*—The weight of a bushel of

potatoes is 60 pounds. As the average amount of fermentable matter in potatoes grown in the United States is 20 per cent, the total weight of fermentable matter in a bushel of potatoes is 12 pounds, which would yield approximately 6 pounds or 3.6 quarts of alcohol.

The quantity of starch in American-grown potatoes varies from 15 to 20 per cent. Probably 18 per cent might be stated as the general average of the best grades of potatoes.

Under the microscope the granules of potato starch have a distinctive appearance. They appear as egg-shaped bodies on which, especially the larger ones, various ring-like lines are seen. With a modified light under certain conditions of observation a black cross is developed upon the granule. It is not difficult for an expert microscopist to distinguish potato from other forms of starch by this appearance.

The potato contains very little material which is capable of fermentation aside from starch and sugars.

Although the potato is not sweet to the taste in a fresh state, it contains notable quantities of sugar. This sugar is lost whenever the potato is used for starch-making purposes, but is utilized when it is used for the manufacture of industrial alcohol. The percentage of sugar of all kinds in the potato rarely goes above 1 per cent. The average quantity is probably not far from 0.35 per cent, including sugar, reducing sugar, and dextrin, all of which are soluble in water. In the treatment of potatoes for starch making, therefore, it may be estimated that 0.35 per cent of fermentable matter is lost in the wash water.

*Average Composition.*—The average composition of potatoes is:

Water.....	75.00 per cent
Starch.....	19.87 per cent
Sugars and dextrin.....	.77 per cent
Fat.....	.08 per cent
Cellulose.....	.33 per cent
Ash.....	1.00 per cent

According to Maercker, the sugar content, including all forms of sugar, varies greatly. Perfectly ripe potatoes contain generally no sugar or only a fractional per cent. When potatoes are stored under unfavorable conditions, large quantities of sugar may be developed, amounting to as high as 5 per cent altogether. In general, it may be stated that the content of sugar of all kinds will vary from 0.4 per cent to 3.4 per cent, according to conditions.



The liberal application of nitrogenous fertilizers increases the yield per acre of tubers and of starch to a very marked extent, although the average percentage of starch present is increased very little.

Of all the common root crops, the potatoes, including the yam and the sweet potato, are the most valuable for the production of alcohol, meaning by this term that they contain more fermentable matter per 100 pounds than other root crops.

While sugar beets, carrots, and parsnips contain relatively large amounts of fermentable matter, these roots could not compete with potatoes even if they could all be produced at the same price per 100 pounds.

A general review of all the data indicates that under the most favorable circumstances and with potatoes which have been grown especially for the purpose an average content of fermentable matter of about 20 per cent may be reasonably expected. It is thus seen that approximately 10 pounds of industrial alcohol can be made from 100 pounds of potatoes. If 60 pounds be taken as the average weight of a bushel of potatoes, there are found therein 12 pounds of fermentable matter, from which 6 pounds of industrial alcohol can be produced, or  $\frac{1}{2}$  of a gallon. It has also been shown that the amount of Indian corn necessary for the production of a gallon of industrial alcohol costs not less than 15 cents. From this it is evident that the potatoes for alcohol making will have to be produced at a cost not to exceed 15 cents per bushel, before they can compete with Indian corn for the manufacture of industrial alcohol.

**Rice.**—Rice is not used to any great extent in this country for making alcohol, but it is extensively used for this purpose in Japan and some other countries, and has the largest percentage of fermentable matter of all the cereals. The percentage of fermentable matter in rice is nearly 78 per cent. A bushel of rice weighs, unhulled, 45 pounds, hulled, 56 pounds, and it therefore has about 34 and 43 pounds, respectively, of fermentable matter for the unhulled and the hulled rice. It is not probable that rice will ever be used to any extent in this country as a source of industrial alcohol, although it is used to a large extent in the manufacture of beverages, as for instance in beers, which are often made partly of rice.

**Rye.**—Large quantities of alcohol, chiefly in the form of alcoholic beverages, are manufactured from rye. It is, in

connection with Indian corn, the principal source of the whiskies made in the United States. Rye, however, is not used to any extent in this or other countries for making industrial alcohol.

Rye contains almost as much fermentable matter as Indian corn. A bushel of rye weighs 56 pounds. Wheat and other cereals, not mentioned above, are not used in this country to any appreciable extent in the manufacture of alcohol.

**Spelt.**—This grain, which is botanically a variety of wheat, more closely resembles barley. Under favorable conditions as much as 73 bushels per acre have been reported, and analyses show 70 per cent of fermentable carbohydrates. The weight per bushel is about the same as that of oats. It would appear that this crop might be worthy of consideration as a profitable source of industrial alcohol.

**Sugar Beets.**—The sugar beet is often used directly as a source of alcohol. Working on a practical scale in France, it has been found that from 10,430 tons of beets there were produced 188,624 gallons of crude alcohol of 100 per cent strength. The beets contain 11.33 per cent of sugar. From 220 pounds of sugar 15.64 gallons of alcohol were produced. The weight of pure alcohol obtained is a little less than one-half the weight of the dry fermentable matter calculated as sugar subjected to fermentation. About 18 gallons of alcohol are produced for each ton of sugar beets employed.

**Sweet Potatoes.**—Experiments show that as much as 11,000 pounds of sweet potatoes can be grown per acre. The average yield of sweet potatoes, of course, is very much less. On plots to which no fertilizer is added the yield is about 8,000 pounds of sweet potatoes per acre, yielding in round numbers 1,900 pounds of starch. The quantity of sugar in the 8,000 pounds is about 350 pounds, which, added to the starch, makes 2,250 pounds of fermentable matter per acre. This will yield 1,125 pounds of industrial alcohol of 95 per cent strength, or approximately 160 gallons per acre. The percentage of starch is markedly greater than in the white or Irish potato. In all cases over 20 per cent of starch was obtained in the South Carolina sweet potatoes, and in one instance over 24 per cent. As much as 2,600 pounds of starch were produced per acre.

In addition to starch, the sweet potato contains notable quantities of sugar, sometimes as high as 6 per cent being present, so that the total fermentable matter in the sweet potato may be reck-



oned at the minimum at 25 per cent. A bushel of sweet potatoes weighs 55 pounds, and one-quarter of this is fermentable matter, or nearly 14 pounds. This would yield, approximately, 7 pounds, or a little over 1 gallon of 95 per cent alcohol. It may be fairly stated, therefore, in a general way, that a bushel of sweet potatoes will yield 1 gallon of industrial alcohol.

Experiments have shown that the quantity of starch diminishes and the quantity of sugar increases on storing. Further, it may be stated that in the varieties of sweet potatoes which are most esteemed for table use there is less starch and perhaps more sugar than stated above. The total quantity of fermentable matter, however, does not greatly change, although there is probably a slight loss.

**Utilization of Waste Material or By-Products. — Molasses.** — The utilization of the waste materials from the sugar factories and sugar refineries for the purpose of making alcohol is a well-established industry. The use of these sources of supply depends, of course, upon the cost of the molasses. When the sugar has been exhausted as fully as possible from the molasses the latter consists of a saccharine product, containing a considerable quantity of unfermentable carbohydrate matter, large quantities of mineral salts, and water. In molasses of this kind there is probably not more than 50 pounds of fermentable matter to 100 pounds of the product. Assuming that a gallon of such molasses weighs 11 pounds, it is seen that it contains  $5\frac{1}{2}$  pounds of fermentable matter, yielding  $2\frac{1}{4}$  pounds of industrial alcohol of 95 per cent strength. It requires about 3 gallons of such molasses to make 1 gallon of industrial alcohol.

When the price of molasses delivered to the refineries falls as low as 5 or 6 cents a gallon it may be considered a profitable source of alcohol.

**Wood Pulp and Sawdust.** — Many attempts have been made to produce alcohol for industrial purposes from sawdust, wood pulp, or waste wood material. The principle of the process rests upon the fact that the woody substance is composed of cellulose and kindred matters which, under the action of dilute acid (preferably sulphuric or sulphurous) and heat, with or without pressure, undergo hydrolysis and are changed into sugars. A large part of the sugar which is formed is non-fermentable, consisting of a substance

known as xylose. Another part of the sugar produced is dextrose, made from the true cellulose which the wood contains.

The yield of alcohol in many of the experiments which have been made has not been very satisfactory. It is claimed, however, by some authors that paying quantities of alcohol are secured. In Simonsen's process for the manufacture of alcohol  $\frac{1}{2}$  per cent sulphuric acid is employed and from 4 to 5 parts of the liquid heated with 1 part of the finely comminuted wood for a quarter of an hour under a pressure of 9 atmospheres. It is claimed by Simonsen that he obtained a yield of 6 quarts of alcohol from 110 pounds of air-dried shavings. Another process which has been tried in this and other countries for converting comminuted wood into alcohol is known as Classen's. The comminuted wood is heated for 15 minutes in a closed apparatus at a temperature of from 248° to 293° F. in the presence of sulphurous acid (fumes of burning sulphur) instead of sulphuric acid. It is claimed by the inventor that he has made as much as 12 quarts of alcohol from 110 pounds of the air-dried shavings. There is reason to doubt the possibility of securing such high yields in actual practice as are claimed in the above processes. That alcohol can be made from sawdust and wood shavings is undoubtedly true, but whether or not it can be made profitably must be determined by actual manufacturing operations.

**Waste Products of Canneries, etc.** — The principal waste materials which may be considered in this connection are the refuse of wine making, fruit evaporating, and canning industries, especially the waste of factories devoted to the canning of tomatoes and Indian corn. In addition to this, the waste fruit products themselves, which are not utilized at all, as, for instance, the imperfect and rotten apples, tomatoes, grapes, etc., may be favorably considered. The quantity of waste products varies greatly in different materials.

The quantities of waste material in grapes and apples, as shown by Lazenby, are as follows: About 25 per cent of the total weight in grapes, with the exception of the wild grape, where it is about 60 per cent; with apples the average percentage of waste was found to be 23.8 per cent from 25 varieties. This included the waste in the core, skin, and the defective apples caused by insects, fungi, bruises, etc. In general it may be said that in the preparation of fruits for



preserving purposes about 25 per cent of their weight is waste, and this, it is evident, could be utilized for the manufacture of alcohol. If apples be taken as a type of fruits, we may assume that the waste portions contain 10 per cent of fermentable matters, which, however, is perhaps rather a high estimate. Five per cent of this might be recovered as industrial alcohol. Thus, each 100 pounds of fruit waste in the most favorable circumstances might be expected to produce 5 pounds of industrial alcohol. The quantity of waste which could be utilized for this purpose would hardly

established it might be profitable to devote them to this purpose.

**Manufacture of Alcohol.**—The three principal steps in the manufacture of alcohol are (1) the preparation of the mash or wort, (2) the fermentation of the mash or wort drawn off from the mash tun, and (3) the distillation of the dilute alcohol formed in the beer or wash from the fermentation tanks. The preparation of the mash includes (1) the treatment of the material used with hot water to form a paste of the starch or the sugar, and (2) the action of the malt or ferment

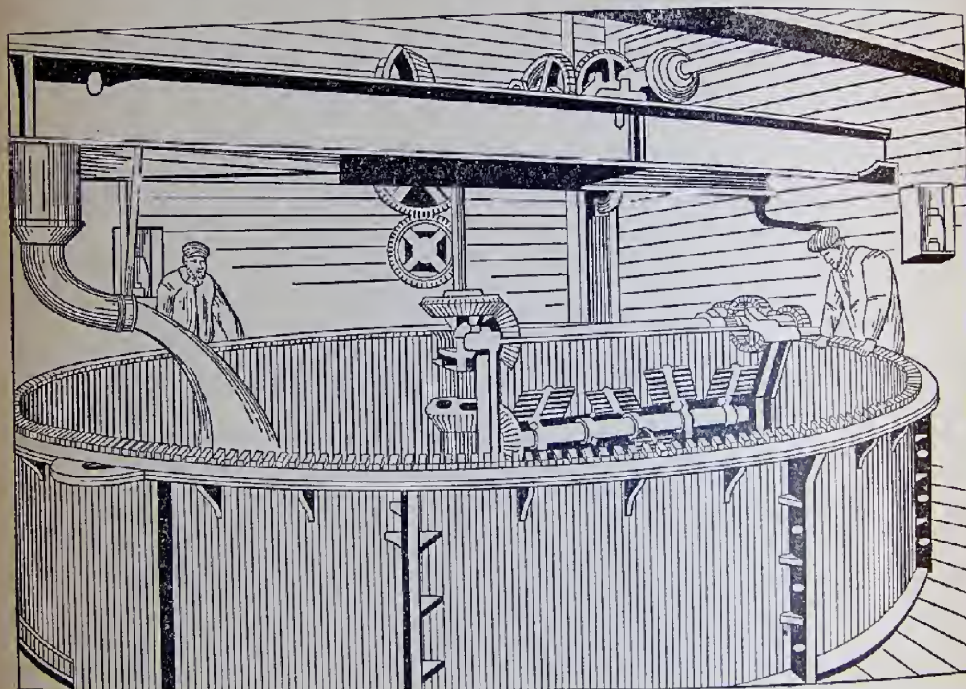


FIG. 1.—MASH TUN IN AN IRISH DISTILLERY.

render it profitable to engage in the manufacture. A smaller percentage could be expected from the waste of the tomato, where the quantity of sugar is not so great. In the waste of the sweet-corn factory the amount of fermentable matter would depend largely on the care with which the grain was removed. There is usually a considerable quantity of starchy material left on the cobs, and this, with the natural sugars which the grown cobs contain, might yield quite large quantities of fermentable matter. It would not be profitable to erect distilleries simply for the utilization of waste of this kind, but if these wastes could be utilized in distilleries already

on the paste to convert the starch into fermentable sugar.

**Mashing.**—Figs. 1 and 2 show two views of the mashing tun or tank, the first figure giving the general appearance, and the second a view of the interior of the tun, showing the machinery by which the stirring is effected and the series of pipes for cooling the finished product down to the proper temperature for the application of the malt.

The object of the mash tun is to reduce the starch in the ground grain to a pasty, gummy mass, in order that the ferment of the malt may act upon it vigorously and convert it into sugar. If the mashing be done before the addition



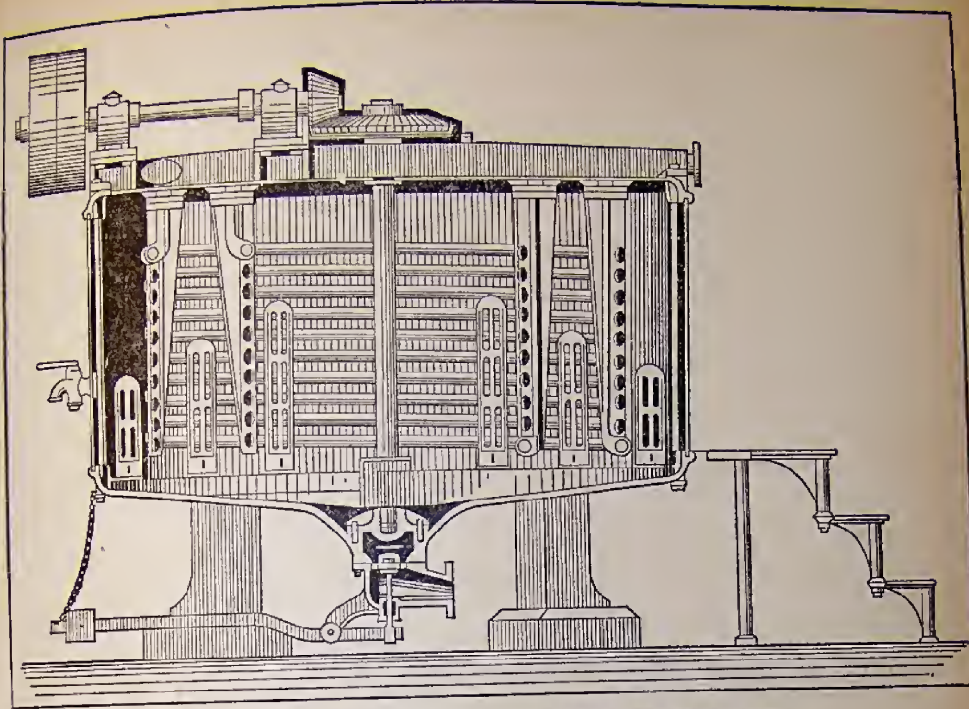


FIG. 2.—MASHING AND COOLING APPARATUS, CROSS SECTION.

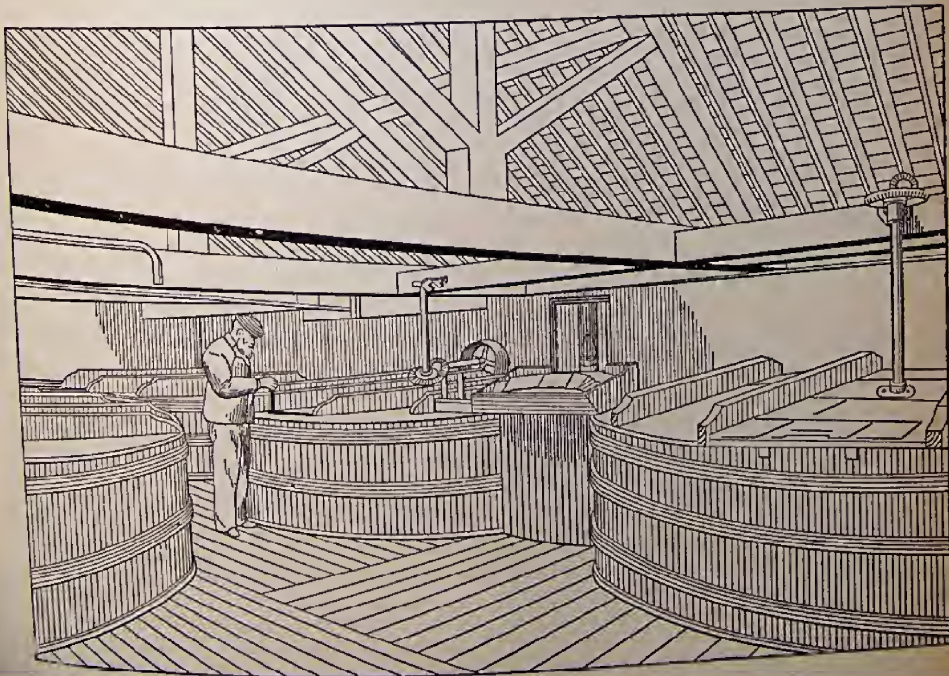


FIG. 3.—FERMENTATION TANKS IN AN IRISH DISTILLERY.



of the malt the temperature may be raised to that of boiling water. If, however, the malt be added before the mashing begins, the temperature should not rise much, if any, above 140° F., since the fermenting power is retarded and the disturbed at higher temperatures. The mashing is simply a mechanical process by means of which the starch is reduced to a form of paste and the temperature maintained at that point which is best suited to the conversion of the starch into sugar.

**Fermentation.**—The mash, after the starch has all been converted into sugar, goes into fermenting tanks, which in Scotland are called "wash backs," when the yeast is added. A view of the typical wash back is shown in Fig. 3. They often have a stirring apparatus, as indicated in the figure, whereby the contents can be thoroughly mixed with the yeast and kept in motion. This is not necessary after the fermentation is once well established, but it is advisable, especially in the early stages, to keep the yeast well distributed throughout the mass. In these tanks the fermentations are conducted, the temperature being varied according to the nature of the product to be made. For industrial alcohol the sole purpose should be to secure the largest possible percentage of alcohol without reference to its palatable properties.

An organism belonging to the vegetable family and to which the name "yeast" has been given is the active agent in fermentation. The organism itself does not take a direct part in the process, but it secretes another ferment of an unorganized character known as an "enzym" or a "diastase." This enzym has the property, under proper conditions of food, temperature, and dilution, of acting upon sugar and converting it into alcohol and carbonic acid. Anyone who has ever seen a fermenting vat in full operation and noticed the violent boiling or ebullition of the liquor, can understand how rapidly the gas "carbon dioxide" or "carbonic acid," as it is usually called, may be formed, as it is the escape of this gas which gives the appearance to the tank of being in a violent state of ebullition. The yeast which produces the fermentation belongs to the same general family as the ordinary yeast which is used in the leavening of bread. The leavening of bread under the action of yeast is due to the conversion of the sugar in the dough into alcohol and carbon dioxide or carbonic acid. The gas thus formed becomes

entangled in the particles of the gluten, and these expanding cause the whole mass to swell or "rise," as it is commonly expressed. Starch cannot be directly fermented, but must be first converted into sugar, either by the action of a chemical like an acid, or a ferment or enzym, known as diastase, which is one of the abundant constituents of malt, especially of barley malt. In the preparation of a cereal, for instance, for fermentation, it is properly softened and ground, and then usually heated with water to the boiling point or above in order that the starch may be diffused throughout the water. After cooling, it is treated with barley malt, the diastase of which acts vigorously upon the starch, converting it into a form of sugar, namely, maltose, which lends itself readily to the activities of the yeast fermentation. (Fig. 4.)

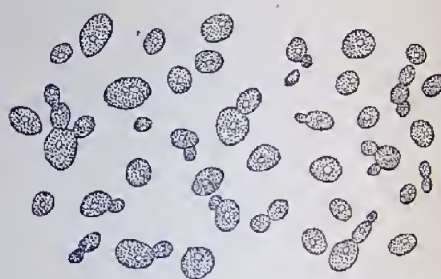


FIG. 4.—YEAST FROM BEER SEDIMENT SHOWING BUDDING (X 1270).

When ordinary sugar (cane sugar, beet sugar, and sucrose) is subjected to fermentation it is necessary that the yeast, which also exerts an activity similar to that of malt, should first convert the cane sugar into invert sugar (equal mixtures of dextrose and levulose) before the alcoholic fermentation is set up. The cane sugar is also easily inverted by heating with an acid.

When different kinds of sugars and starches are fermented for the purpose of making a beverage it is important that the temperature of fermentation be carefully controlled, since the character of the product depends largely upon the temperature at which the fermentation takes place. On the contrary, when industrial alcohol is made, the sole object is to get as large a yield as possible, and for this reason that temperature should be employed which produces the most alcohol and the least by-products, irrespective of the flavor or character of the product made. Also, in the making of alcoholic beverages, it is important that the malt be of the very best quality in



order that the resulting product may have the proper flavor. In the production of alcohol for industrial purposes this is of no consequence, and the sole purpose here should be to produce the largest possible yield. For this reason there is no objection to the use of acids for converting the starch, cane sugar, and cellulose into fermentable sugars. Therefore, the heating of the raw materials under pressure with dilute acids in order to procure the largest quantity of sugar is a perfectly legitimate method of procedure in the manufacture of industrial alcohols.

Sugars and starches are usually associated in nature with another variety of carbohydrates known as cellulose, and this cellulose itself, when acted upon by an acid, is converted very largely into sugars, which, on fermentation, yield alcohol. For industrial purposes, the alcohol produced in this manner is just as valuable as that made from sugar and starch. Whether the diastatic method of converting the starch and sugar into fermentable sugars be used, or the acid method, is simply a question of economy and yield. On the other hand, when alcoholic beverages are to be made, those processes must be employed, irrespective of the magnitude of the yield, which give the finest and best flavors to the products.

**Distillation.**—The object of distillation is to separate the alcohol which has been formed from the non-volatile substances with which it is mixed. A typical form of distilling apparatus for the concentration of the dilute alcohol which is formed in the beer or wash from the fermentation tanks, is represented in Fig. 5.

This apparatus is of the continuous type common to Europe and America. It consists of a "beer still" provided with a number of chambers fitted with perforated plates and suitable overflow pipes. It is operated as follows:

The syrup and alcohol are pumped into the top of the beer still through a pipe *G*; the tank *G* may also be placed above the center of the still and the contents allowed to flow into the still by gravity; steam is admitted through an open pipe into the kettle *A* at the bottom of the column or is produced by heating the spent liquor by means of a coil. The steam ascends through the perforations in the plates, becoming richer and richer in alcohol as it passes through each layer of liquor, while the latter gradually descends by means of the overflow pipes to the bottom of the column *B* and finally reaches the kettle completely exhausted of alcohol, whence it is removed by

means of a pump connected with the pipe line *H*. On reaching the top of the beer still *B* the vapors of the alcohol and the steam continue to rise and pass into the alcohol column *C*. This column is also divided into chambers, but by solid instead of perforated plates, as shown at

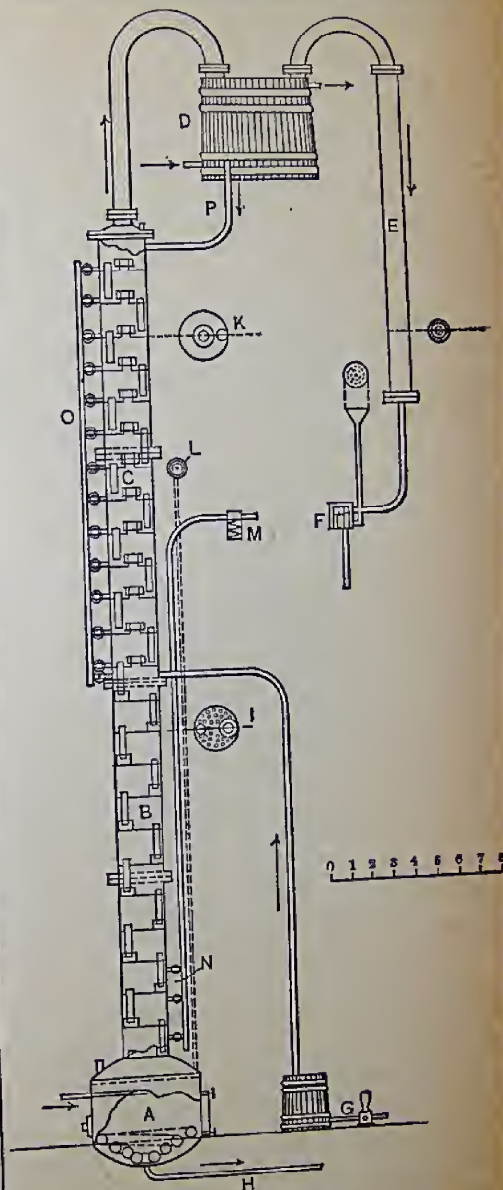


FIG. 5.—CONTINUOUS DISTILLING APPARATUS.

*K.* Each chamber is provided with a return or overflow pipe and an opening through which the vapors ascend. In the alcohol column the vapors are so directed as to pass through a layer of



liquid more or less rich in alcohol which is retained by the plate separating the compartments. An excess of liquids in these compartments overflows through the down pipes, gradually works its way into the beer still, and thence to the kettle. On reaching the top of the column the vapors, which have now become quite rich in alcohol, are passed into a coil provided with an outlet at the lowest part of each bend. These outlets lead into the return pipe *P*, which connects with the top chamber of the alcohol column. This coil is technically termed the "goose" and is immersed in a tank called the "goose tub." A suitable arrangement is provided for controlling the temperature of the water in the tub by means of outlet and inlet water pipes. When the still is in operation the temperature of the "goose" is regulated according to the required density of the alcohol. The object of the "goose" is the return to the column of all low products which condense at a temperature below the boiling point of ethyl alcohol of the desired strength. On leaving the "goose" the vapors enter a condenser *E*, whence the liquid alcohol is conducted into a separator *F*. This separator consists simply of a glass box provided with a cylinder through which a current of alcohol is constantly flowing. An alcohol spindle is inserted in this cylinder and shows the density of the spirit at all times. A pipe, with a funnel-shaped opening at its upper extremity, connects with the pipe leading from the condenser and gives vent to any objectionable fumes. The separator is connected by means of a pipe with the alcohol storage tank. The pipe *O* is for emptying the upper chambers when necessary. The valves *N*, communicating by means of a small pipe with a condenser *M*, are for testing the vapors in the lower chambers for alcohol.

**Substances Used for Denaturing Alcohol.**—The process of rendering alcohol unsuitable for drinking is called "denaturing," and consists, essentially, in adding to the alcohol a substance soluble therein of a bad taste or odor, or both, of an intensity which would render it impossible or impracticable to use the mixture as a drink. Among the denaturing substances which have been proposed are the following:

Gum shellac (with or without the addition of camphor, turpentine, wood spirit, etc.), colophonium, copal rosin, Manila gum, camphor, turpentine, acetic acid, acetic ether, ethylic ether, methyl

alcohol (wood alcohol), pyridine, acetone, methyl acetate, methyl violet, methylene blue, aniline blue, eosin, fluorescein, naphthalene, castor oil, benzine, carbolic acid, caustic soda, musk, animal oils, etc.

Methyl (wood) alcohol and benzine are the denaturing agents authorized in the United States, in the following proportions: To 100 parts, by volume of ethyl alcohol (not less than 90 per cent strength) add 10 parts of approved methyl (wood) alcohol and  $\frac{1}{2}$  of 1 part of approved benzine. Such alcohol is classed as completely denatured. Formulas for special denaturation may be submitted for approval by manufacturers to the Commissioner of Internal Revenue, who will determine whether they may be used or not, and only one special denaturant will be authorized for the same class of industries unless it shall be shown that there is good reason for additional special denaturants. Not less than 300 wine gallons can be withdrawn from a bonded warehouse at one time for denaturing purposes.

**Spirit.**—Proof spirit is a term used by the revenue department in assessing the tax on alcoholic liquors. It means a liquid in which there is 50 per cent (by volume) of absolute alcohol. As it is the actual alcohol in the whisky, brandy, dilute alcohol, etc., which is taxed, and as this varies so widely, it is necessary that the actual wine gallons be converted into proof gallons before the tax rate can be fixed. A sample that is half alcohol and half water (let us say for convenience) is "100 proof." A sample that is  $\frac{3}{4}$  alcohol and  $\frac{1}{4}$  water is 150 proof, and the tax on every gallon of it is  $1\frac{1}{2}$  times the regular government rate per proof gallon. Absolute alcohol is 200 proof and has to pay a double tax.

The legal definition of proof spirit is, "that alcoholic liquor which contains one-half its volume of alcohol of a specific gravity of 0.7939 at 60° F."

## SPONGES:

**Bleaching Sponges.**—I.—Soak in dilute hydrochloric acid to remove the lime, then wash in water, and place for 10 minutes in a 2 per cent solution of potassium permanganate. The brown color on removal from this solution is due to the deposition of manganous oxide, and this may be removed by steeping for a few minutes in very dilute sulphuric acid. As soon as the sponges appear white, they are washed out in water to remove the acid.



surgical operations or for other purposes, should first be washed in warm water, to every quart of which 20 drops of liquor of soda have been added; afterwards washed in pure water, wrung or pressed out and put into a jar of bromine water, where it is left until bleached. Bleaching is accelerated by exposing the vessel containing the bromine water to the direct rays of the sun. When the sponge is bleached it is removed from the bromine water, and put for a few minutes in the water containing soda lye. Finally it is rinsed in running water until the odor of bromine disappears. It should be dried as rapidly as possible by hanging it in the direct sunlight.

**Sterilization of Sponges.**—I.—Allow the sponges to lie for 24 hours in an 8 per cent hydrochloric acid solution, to eliminate lime and coarse impurities; wash in clean water, and place the sponges in a solution of caustic potash, 10 parts; tannin, 10 parts; and water, 1,000 parts. After they have been saturated for 5 to 20 minutes with this liquid, they are washed out in sterilized water or a solution of carbolic acid or corrosive sublimate, until they have entirely lost the brown coloring acquired by the treatment with tannin. The sponges thus sterilized are kept in a 2 per cent or 15 per cent carbolic solution.

**Sponge Window Display.**—Soak a large piece of coarse sponge in water, squeeze half dry, then sprinkle in the openings red clover seed, millet, barley, lawn grass, oats, rice, etc. Hang this in the window, where the sun shines a portion of the day, and sprinkle lightly with water daily. It will soon form a mass of living green vegetation very refreshing to the eyes. While the windows are kept warm this may be done at any season. The seeds used may be varied, according to fancy.

#### SPONGES AS FILTERS:

See Filters.

#### SPONGE CLEANERS:

See Cleaning Preparations and Methods, under Miscellaneous Methods.

#### SPONGE-TRICK, BURNING:

See Pyrotechnics.

#### SPOT ERADICATORS:

See Cleaning Preparations and Methods and Soaps.

#### SPOT GILDING:

See Plating.

#### SPRAY SOLUTION:

See Balsams.

#### SPRAY FOR HOUSE FLY:

Eucalyptol .....	10 ounces
Bergamot oil .....	3 ounces
Acetic ether .....	10 ounces
Cologne water .....	50 ounces
Tincture of insect powder	50 ounces

Mix all of these ingredients well. One part of this mixture in 10 parts of water and sprayed around the room will kill all flies and insects.

#### SPRINGS OF WATCHES:

See Watchmakers' Formulas.

#### SPRUCE BEER:

See Beverages.

#### STAIN REMOVERS:

See Cleaning Preparations and Methods.

#### STAINS:

See Paints, Varnishes and Wood Stains.

#### STAINS FOR LACQUERS:

See Lacquers.

## Stamping

(See also Dyes.)

**Stamping Colors for Use with Rubber Stamps.**—Blue: 0.3 parts of water-blue 1 B, 1.5 parts of dextrin, 1.5 parts of distilled water. Dissolve the aniline dye and the dextrin in the distilled water, over a water bath, and add 7 parts of refined glycerine, 28° Bé.

Other colors may be made according to the same formula, substituting the following quantities of dyes for the water-blue: Methyl violet 3 B, 0.02 parts; diamond fuchsine I, 0.02 parts; aniline green D, 0.04 parts; vesuvine B, 0.05 parts; phenol black, 0.03 parts. Oleaginous colors are mostly used for metallic stamps, but glycerine colors can be used in case of necessity.

**Oleaginous Stamping Colors.**—Mix 0.8 parts of indigo, ground fine with 2.5 parts of linseed-oil varnish, and 0.5 parts of olein. Add 2 parts of castor oil and 5 parts of linseed oil. For other colors according to the same formula, use the following quantities: Cinnabar, 2½ parts; verdigris, 2½ parts; lampblack, 1.2 parts; oil-soluble aniline blue A, 0.35 parts; oil-soluble aniline scarlet B, 0.3 parts; aniline yellow (oil-soluble), 0.45 parts; oil-soluble aniline black L, 0.6 parts.

**Stamping Liquids and Powders.**—Dissolve 1 drachm each of rosin and copal



in 4 fluidounces of benzine and with a little of this liquid triturate  $\frac{1}{2}$  drachm of Prussian blue and finally mix thoroughly with the remainder.

Ultramarine, to which has been added a small proportion of powdered rosin, is generally used for stamping embroidery patterns on white goods. The powder is dusted through the perforated pattern, which is then covered with a paper and a hot iron passed over it to melt the rosin and cause the powder to adhere to the cloth. The following are said to be excellent powders:

I.—White.—One part each of rosin, copal, damar, mastic, sandarac, borax, and bronze powder, and 2 parts white lead.

II.—Black.—Equal parts of rosin, damar, copal, sandarac, Prussian blue, ivory black, and bronze powder.

III.—Blue.—Equal parts of rosin, damar, copal, sandarac, Prussian blue, ultramarine, and bronze powder.

In all these powders the gums are first to be thoroughly triturated and mixed by passing through a sieve, and the other ingredients carefully added. Other colors may be made by using chrome yellow, burnt or raw sienna, raw or burnt umber, Vandyke brown, etc. For stamping fabrics liable to be injured by heat, the stamping is done by moistening a suitable powder with alcohol and using it like a stencil ink.

**Stamping Powder for Embroideries.**—“Stamping powders” used for outlining embroidery patterns are made by mixing a little finely powdered rosin with a suitable pigment. After dusting the powder through the perforated pattern it is fixed on the fabric by laying over it a piece of paper and then passing a hot iron carefully over the paper. By this means the rosin is melted and the mixture adheres. When white goods are to be “stamped,” ultramarine is commonly used as the pigment; for dark goods, zinc white may be substituted. Especial care should be taken to avoid lead compounds and other poisonous pigments, as they may do mischief by dusting off. On velvets or other materials likely to be injured by heat, stamping is said to be done by moistening a suitable powder with alcohol and using it as stencil paint. A small addition of resinous matter would seem required here also.

### Starch

**Black Starch.**—Add to the starch a certain amount of logwood extract be-

fore the starch mixture is boiled. The quantity varies according to the depth of the black and the amount of starch. A small quantity of potassium bichromate dissolved in hot water is used to bring out the proper shade of black. In place of bichromate, black iron liquor may be used. This comes ready prepared.

**Starch Gloss.**—I.—Melt 2½ pounds of the best paraffine wax over a slow fire. When liquefied remove from the fire to stir in 100 drops of oil of citronella. Place several new pie tins on a level table, coat them slightly with sweet oil, and pour about 6 tablespoonfuls of the melted paraffine wax into each tin. The pan may be floated in water sufficiently to permit the mixture to be cut or stamped out with a tin cutter into small cakes about the size of a peppermint lozenge. Two of these cakes added to each pint of starch will cause the smoothing iron to impart the finest possible finish to muslin or linen, besides perfuming the clothes.

II.—Gum arabic, powdered . . . . . 3 parts  
Spermaceti wax . . . . . 6 parts  
Borax, powdered . . . . . 4 parts  
White cornstarch . . . . . 8 parts

All these are to be intimately mixed in the powder form by sifting through a sieve several times. As the wax is in a solid form and does not readily become reduced to powder by pounding in a mortar, the best method of reducing it to such a condition is to put the wax into a bottle with some sulphuric or rectified ether and then allow the fluid to evaporate. After it has dissolved the wax, as the evaporation proceeds, the wax will be deposited again in the solid form, but in fine thin flakes, which will easily break down to a powder form when rubbed up with the other ingredients in a cold mortar. Pack in paper or in cardboard boxes. To use, 4 teaspoonfuls per pound of dry starch are to be added to all dry starch, and then the starch made in the usual way as boiled starch.

**Refining of Potato Starch.**—A suitable quantity of chloride of lime, fluctuating according to its quality between  $\frac{1}{2}$  to 1 part per 100 parts of starch, is made with little water into a thick paste. To this paste add gradually with constant stirring 10 to 15 times the quantity of water, and filter.

The filtrate is now added to the starch stirred up with water;  $\frac{1}{2}$  part of ordinary